

One of the most severe rain and wind storms that has visited this section in many years occurred on the night of the 9th and early morning of the 10th, the wind along the coast and at sea blowing a gale for many hours, causing a great deal of damage to coastwise shipping, piers, docks, etc., along the southern coast. At Newport Beach the wind swept up the harbor during the entire night, wrecking a number of power launches and other small craft, and sinking a steam dredger belonging to the Collins Commercial Co. Among the launches to suffer damage were the *Emily*, *Rover*, *Charlotte*, and *Tommae*. The old Southern Pacific wharf was blown to pieces, as well as the bulkhead along the ocean front below Balboa. The greatest damage to property occurred at Long Beach, where the pleasure pier, built some 7 years ago at a cost of several hundred thousand dollars, was partially destroyed.

The waves dashed over the pier all Saturday night and by Sunday morning the beach was strewn with wreckage. The entire outer part of the pier, approximately 100 by 80 feet in size was washed away, up to the south wall of what is known as the "sun parlor." The loss is estimated at about \$30,000. Two lives are known to have been lost during the storm, both men being fishermen. The steamer *Yosemite* arrived in Los Angeles harbor about 2 p. m. Sunday, after having battled with the storm for hours Saturday night. She had a propeller shaft broken, and lost much of her deck load of lumber in the storm. The captain and crew of the vessel report the most severe gale they have experienced in years. All incoming shipping report terrific winds at sea Saturday night, and all arrived in a more or less damaged condition.

Electric light, telephone, and telegraph wires suffered from the high winds, while several small dwellings in the course of erection were blown down. Storm warnings were displayed well in advance of the storm.

Notwithstanding the long dry spell, the heavy rains caused a rapid rise in the San Gabriel River, and some minor washouts occurred at several places, but no serious damage resulted. Heavy rain warnings were sent out to the transportation and water companies to prepare for a rapid rise in all streams.

The storm moved in from the ocean over southern California, causing the lowest barometer reading in this section of which there is a record. At Los Angeles the lowest pressure reading, reduced to sea level, was 29.26.

Mr. T. S. Manning, storm warning displayman at Avalon, Catalina Island, commenting on the storm writes as follows:

It rained hard all day of the 9th, with wind from east to northeast. Barometer fell steadily, the last reading taken at 10 p. m., being 29.28, a drop of 66 points from 5 o'clock Friday. Wind shifted to SE, by going around to NW, W, and S. Precipitation for the storm 3 inches. Gales from southeast all night blowing down some 50 trees. No damage in harbor, as wind was off shore. Capt. Matthews of the *Comfort* reports his glass at 29.20 at 2 a. m., of the 10th. The steamer *Cabrillo* unable to face the storm Sunday morning, was forced to turn back to San Pedro.

Following closely the storm of the 9th-10th came the one which moved inland over northern California on the night of March 11, and while the rainfall was heavy in southern California, the winds did not attain as high velocity over the inland sections as during the previous blow. The storm was severe along the coast and at sea, however, and all incoming steamers reported heavy seas and high winds outside. The oil steamer *Rosecrans* was wrecked near Gaviota, Cal., at 4 a. m., on the morning of the 12th, resulting in the loss of the vessel and two of the crew. Storm warnings were displayed for this storm.

Special rain warnings were issued to transportation and water companies to prepare for high water in the several rivers of the south. No damage resulted from high water.

THE SEVERE COLD OF DECEMBER 25-26, 1911, IN THE CITRUS DISTRICTS OF SOUTHERN CALIFORNIA, AND METHODS ADOPTED FOR FRUIT PROTECTION.

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The fall and early winter of 1911 stand out prominently among recent years as particularly disastrous to the citrus-fruit interests of southern California, a continued cold period of about 50 days, culminating on December 25 and 26 in a freeze among the most severe ever experienced in this locality. The freeze was much more widespread than that of two seasons ago, and while some groves that were badly frozen in 1908 and 1909 escaped practically without injury this year, many sections hitherto considered immune from frost suffered greatly during the present cold spell. The damage was about equally distributed over the high and low lands, orchards on the higher levels suffering quite as much in places as those in the valleys below.

As the conditions which preceded the cold spell undoubtedly contributed largely to the damage which resulted, a consideration of these conditions may help to a more intelligent discussion of the subject. From November 1 to December 31, 1911, there were only three fairly well-defined storms which entered the North Pacific States and moved southward over the Pacific slope, these movements taking place on November 10, December 17, and 27. All of these caused light precipitation at scattered places in southern California, but all moved too far inland to effectually break the long continued drought prevailing in this section at the time.

There was, however, a well-defined storm movement from the Gulf of California northeastward over the Colorado River Valley, the storms remaining in that locality from 24 to 36 hours, then moving eastward or northeastward to points where they ceased to be a factor in the weather of the Southwest. During most of the time under consideration the pressure was high over the Pacific Northwest and the northern Rocky Mountain region, which caused a general drift of the surface air from the north over southern California. It is said by old residents that there was more cold north wind in this section during the months of November and December, 1911, than had been known for a great many years. This statement is in a measure verified by the actual wind movement in Los Angeles, the only point in the vicinity of the fruit belt where a record of the velocity of the wind is made. The prevailing direction for both months in Los Angeles was from the northeast, with an average hourly velocity of 6.1 miles an hour for November and 7.5 miles for December. The average hourly velocity in this city for November and December, taken from all records (35 years), is 4.1 and 4.4 miles, respectively. The total movement of the wind in miles for November was 4,419, almost breaking the record, and 5,614 for December, the greatest number of miles ever recorded for this month since the establishment of the station in 1877.

In nearly all sections of the fruit belt the wind was almost constantly from the north, with unusually high velocities in many places, the continued cold north wind causing the soil to dry out and lose much of its accumulated heat. A fairly good idea of the extreme dryness prevailing at the time of the severe freeze may be had

from an inspection of the records of the self-registering hygrographs installed by the Weather Bureau in Los Angeles, Pasadena, and Claremont, Cal., and at the ranch of Mr. R. B. Thompson in Highland, Cal., where a self-registering apparatus was also in operation. (See tables at end of this article.)

It is to be regretted that an hourly record of the temperature for the same period is not available, so that these two important factors might be considered together. In a few cases we are able to show the temperatures, by hours, during the cold spell, but as a rule only the eye readings of the ranchers are obtainable.

On December 25, 1911, the weather reports received at the local office showed a depression central over Arizona and a high pressure area over northern California and covering most of the Central Pacific slope. Temperatures near zero obtained in Nevada, while in Utah they were below zero. Zero temperatures also prevailed over the intermountain region of the northwest, and taken as a whole the pressure and temperature distribution over the western half of the United States that morning were about as favorable for a severe frost in southern California during the following night as one could expect to find them. Warnings of severe frost were issued by the Weather Bureau and disseminated to the growers in the usual manner.

As soon as possible after the freeze, under authority of the Chief of the Weather Bureau, the writer visited the citrus-fruit sections of southern California and collected such information as was available regarding the severity and duration of the low temperatures, the damage done, and the measures taken to protect the orchards against frost, in order that it might be available for future study. Only such records as were known to be reliable were considered, and special attention was given to the make of thermometers and their exposures. For convenience' sake the several fruit-growing sections are considered alphabetically.

Azusa, Los Angeles County.—Lowest temperature 22° on the morning of December 26. The temperature remained below the danger point for about 12 hours. Some smudging done, with variable results. Temperature raised from 26° to 31° in some orchards. The table at the end of this article gives temperature by hours, the record being taken from a Draper thermograph exposed on the property of the Azusa Foothill Citrus Co. for the week ended at 7 a. m., December 26, 1911.

At a point 2 miles south of the Santa Fe Railroad depot at Azusa, the temperature was 28°. The thermometer from which this record was obtained is the property of the Weather Bureau and is exposed in a regulation instrument shelter.

Colton, San Bernardino County.—The lowest temperature was 19°, on the morning of December 26. The temperature fell to the danger point about 10 p. m. December 25, and remained at or below that point for 6 to 8 hours. Smudging not general in this district, and much damage resulted.

Corona, Riverside County.—The lowest temperature recorded by a reliable thermometer properly exposed was 20° on the morning of December 26. All Christmas Day the thermometer registered in the neighborhood of 50°, and by 10.30 p. m. the temperature had dropped to 28°. By 1 a. m. of the 26th it registered 22°, and at 4 a. m. 20°, remaining at that point until 7 a. m. The temperature was almost uniform over the slope, the 1,000-foot level showing quite as cold as at 600 feet. The cold wave came in from the southeast down the Temescal Canyon

and moved westward across the mesa. Smudging was only carried on by a few growers, and where thoroughly done was very effective, saving practically all the young lemons. The smoke from the smudged orchards saved a considerable area of oranges in the vicinity of each orchard smudged, but was not sufficient to protect lemons to any great extent except in the immediate neighborhood of the fires. Hourly eye readings were taken at the ranch of Mr. Thomas C. Sias from a tested self-registering minimum thermometer, and appear at the end of this article.

The temperature was below the danger point in this district from 10 to 12 hours.

Claremont, Los Angeles County.—The only reliable temperature record obtainable in this section was from a regular Weather Bureau thermometer at the cooperative station at Pomona College. The thermometer is exposed in a regulation shelter and is about 5 feet above the ground. The lowest temperature on the morning of December 26 was 27°. The length of time the temperature was below the danger point could not be ascertained. It is not thought this temperature is representative of the conditions in the orchards near the town, especially below the Santa Fe Railroad tracks, where it was undoubtedly colder.

Covina, Los Angeles County.—The lowest temperature recorded in this city on the morning of December 26 was 28°. There is no record of how long the temperature remained at that point. No smudging done in this district. Orchards badly frozen 2 years ago escaped uninjured this year.

Duarte, Los Angeles County.—On the lower levels the temperature fell to 21° on the morning of December 26. The temperature was down to the freezing point about 9 p. m. Christmas night, and then fell gradually to the lowest point recorded the following morning. It is quite probable the temperature was below the danger point in this district from 8 to 10 hours. Smudging was not generally carried on, and much damage resulted.

Fillmore, Ventura County.—The lowest temperature was 23°, on Christmas morning. The conditions in this section are somewhat different than those which obtain in the fruit belt proper, owing to the location. On the 26th the temperature fell to 26°. On each morning it was below the danger point for about 4 hours. Smudging not general nor was it well done. On the Sparr Fruit Co.'s orchards one pot was exposed to a tree, and these were fired when the temperature fell to 30°. About \$15,000 worth of fruit was saved at a cost of about \$500 for fuel and labor.

Glendora, Los Angeles County.—No reliable temperature readings obtainable in this district in the immediate vicinity of the town. From what could be learned from reliable sources, however, the temperature over this district varied very materially in short distances. Such localities as are free and open to the circulation of the air were quite free from cold sufficiently intense to injure citrus fruit.

Highland, San Bernardino County.—The only reliable temperature record obtainable at this place was made at the ranch of Mr. R. B. Thompson. This ranch is located about four or five hundred feet above the floor of the valley. The lowest temperature recorded here on the morning of December 26 was 28°, but much lower temperatures must have occurred below the base line road. No hourly temperature kept. A self-registering hydrograph is located on the ranch, and the uncorrected readings of this instrument are to be found at the end of this article. There was no smudging done in this section.

Highgrove, Riverside County.—The temperature over this district varied greatly according to location. At a point, midway between what is considered doubtful orange location and the mountain, which has never been affected by frost, the temperature registered 22° at 11.30 p. m. Christmas night, dropped to 20° in an hour, and remained there until 7.30 a. m. the next morning, with the exception of a very short time, when it registered 19°. Smudging carried on over a comparatively small area and was effective according to the thoroughness with which it was done.

Lordsburg, Los Angeles County.—The lowest temperature on the morning of December 26 was 22°. The temperature was below the danger point about 3 hours. No smudging to speak of in this district.

Monrovia, Los Angeles County.—Lowest temperature between 22° and 26° according to location. No reliable data obtainable as to how long the temperature remained below the danger point, but in all probability the conditions in this section did not differ materially from others in the immediate vicinity. No general protection work carried on here.

Ontario, San Bernardino County.—So far as could be ascertained the lowest temperature recorded in this district was 22°, on the morning of December 26. The temperature remained below the danger point from 7 to 12 hours, according to location. Considerable smudging done in this section, with good results where properly handled.

Orange, Orange County.—The lowest temperature in this district is given as 30°, but no reliable data could be found regarding the correct temperature in this district. The readings were not made from self-registering thermometers, and those obtained only represented the conditions at the time of reading the instrument, and it is quite probable that lower temperatures did occur on the morning of December 26. Some damage done to small trees, new growth on old trees, and the crop in general. Some smudging done, and generally effective. Two or three ranchers are said to have saved all their young lemons by firing.

Pomona, Los Angeles County.—Through the courtesy of the San Antonio Fruit Exchange we are able to present hourly temperature readings at several points in this district. The thermographs are properly exposed and nearly accurate, and are exposed at widely separated points so as to cover the district as thoroughly as possible. The hourly temperature readings appear at the end of this article.

Mr. J. E. Adamson, whose ranch, Los Palmas, is located at the corner of Weber and Arroyo Avenues, kept a careful record of temperature during the cold spell, supplementing an excellent record made by a Frieze hygro-thermograph. Mr. Adamson's remarks follow:

On the night of the 25th the temperature went to 32° at 7 p. m. and continued to drop steadily outside the fire zone, reaching 18° at about 2 a. m. and touching 17° for a short time between 6 and 7 a. m. On the morning of the 27th it reached 22° for a short time. Smudging was resorted to quite generally in our vicinity, with success in proportion to the equipment. The best work was done by those having oil pots of 2 gallons or larger, but some loss was felt in making the fight with the 1-gallon pots. Nothing but oil was used in this vicinity. The gain from smudging was 7° with fires burning one to the tree, using 1 gallon of oil in seven hours. Where there were bigger pots there was no trouble to make 10° when burning 1 gallon per tree in five hours.

Riverside, Riverside County.—This district suffered great loss in this freeze, the temperature remaining below the danger point for fully 10 hours. Highland and low-

land suffered about equally, and many sections hitherto considered immune from frost damage were badly frozen. Reliable temperature records show a minimum temperature between 18° and 20° on the morning of December 26. Mr. F. A. Little, secretary and manager of the Arlington Heights Exchange, says:

We have smudged in our vicinity, viz, Arlington Heights, this season 14 nights, showing that on many occasions the temperature has gotten down to the danger point. The night of the 25th was the coldest of the season in this vicinity, the thermometer registering from 18° to 20°. The temperature remained below the danger point on this night from 8 o'clock in the evening of the 25th until the next morning. Smudging was carried on at the lower levels on Arlington Heights, about four or five hundred acres being smudged. The smudge material used was shavings mixed with oil and asphaltum, only a few using oil pots. From what I have seen where groves have been smudged this year, the trees are in better condition than where they have not been smudged and similarly situated, but while the smudge saved the trees the fruit was injured, as it could not overcome the intense cold.

At the special meteorological station of the Weather Bureau, located at 292 East Seventh Street, the lowest temperature was 21°, on the morning of December 26.

Redlands, San Bernardino County.—At this point hourly temperature readings as recorded by Weather Bureau maximum and minimum thermometers and a Draper thermograph are available and appear at the end of this article.

The temperature was below the danger point between six and eight hours.

San Dimas, Los Angeles County.—The lowest temperature recorded on December 26 was 22°, although the greater portion of the district was not below 28°. It can not be definitely determined how long the temperature remained below the danger point in this district. No smudging in this immediate vicinity. On some of the lower levels and on bottom lands north of the town young nursery stock was not injured in the slightest degree during the cold spell.

Santa Paula, Ventura County.—The following report by Mr. C. C. Teague of the Limonera ranch covers the frost situation in this locality in an excellent manner:

On the night of December 24 the temperature on our ranch dropped as low as 23°. We immediately fired all our oil pots and raised the temperature to 34°. In order to do this we had 56 two-gallon Bolton heaters lighted and 56 coal baskets. During this period thermometers on other portions of the ranch which surround the coldest portion were dropping, and we found it necessary to light up oil pots and baskets in order to keep the temperature above the danger point. After we had raised the temperature on the coldest portion as mentioned above, we put out one-half of our oil pots, by reason of having raised the temperature above the point of danger. Our property is rather isolated and there are no other citrus plantings in that immediate locality, and I regard the thermometers owned by other citrus farmers in that locality as so unreliable that I could not attempt to quote their readings, as they would probably be misleading.

Our experience during the last cold spell convinced us more than ever of the necessity of adequate frost protection equipment. The cold portion of our property is equipped with 112 coal baskets and 56 two-gallon Bolton heaters to the acre. We have come to believe that it is very important that one begin firing early in the night before the heat held by the ground and trees has been entirely lost, and our practice has been to begin firing at the least indication of formation of ice on the trees in the most exposed portions of the groves. We feel convinced that we can handle successfully a temperature lower than 20° for many hours at a time. It is our belief that had the orange districts where damage was so great been as thoroughly equipped as we are, and had this equipment been intelligently handled, there would have been practically no damage.

San Bernardino, San Bernardino County.—The temperature fell to 19° at 6 a. m., December 26, having remained below the danger point from 11 p. m. of the 25th. At 6 p. m., December 25, the temperature was 44°, at 10 p. m., 29°, and at midnight, 25°. At 1 a. m. of the 26th it was 23.5°; 2 a. m., 23°; 6 a. m., 19°. These

readings were made by Dr. A. K. Johnson, special meteorological observer for the Weather Bureau, from regulation Weather Bureau thermometers. Temperatures were below the danger point in this section about 12 hours.

Upland, San Bernardino County.—The temperature in this section on the morning of December 26 ranged from 22° to 26° according to location. It remained below the danger point about 11 hours. Smudging carried on to a limited extent, only about 180 acres being protected in different parts of Upland and upper Ontario from the Mesa down to one-half mile north of the Southern Pacific Railway tracks. Temperature readings were made during the cold spell, the record being taken inside of an orchard, from a thermometer exposed about 4½ feet above

the ground and equidistant between trees. The readings appear at the end of this article.

Whittier, Los Angeles County.—The lowest temperature on the morning of December 26 was 23°, the temperature remaining below the danger point for several hours. The Whittier districts include about 1,400 acres of citrus fruits, and about 35 acres were damaged. This does not apply to the Leffingwell Rancho, an estate of about 600 acres located 4 miles east of Whittier. Through the kindness of Mr. O. B. Griffin, manager of this ranch, we are able to present hourly temperature readings covering the cold spell. Effective frost fighting is done on this ranch, and little or no damage resulted. The readings appear at the end of this article.

Hourly temperature readings.

Date.	Hour (a. m.).												Hour (p. m.).											
	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mid-night.
AZUSA, CAL.																								
Dec. 25, 1911.....	43	43	43	42	40	39	30	38	45	47	49	52	52	52	50	40	34	30	28	28	26	26	26	25
Dec. 26, 1911.....	24	24	23	22	23	22	24																	
CORONA, CAL.																								
Dec. 25, 1911.....																		37			31	31	29	28
Dec. 26, 1911.....	27	25	24	26	23	24	25	27																
POMONA, CAL. (J. E. Adamson Ranch).																								
Dec. 25, 1911.....	43	43	34	38	37	36	31						51	50	50	48	42	35	32	28	28	26	25	27
Dec. 26, 1911.....	25	25	26	25	26	25	23	27	38	43	55	57	60	60	59	56	43	37	32	29	28	30	30	32
POMONA (F. S. Smith Ranch).																								
Dec. 25, 1911.....	28	28	34	36	32	31	29	26	38	50	55	56	57	57	59	61	50	39	31	27	25	24	22	21
Dec. 26, 1911.....	20	19	20	21	20	21	22	23	26	43	52	57	60	62	64	51	39	30	28	25	23	22	22	21
POMONA (Rogers Ranch).																								
Dec. 25, 1911.....	29	35	32	35	36	36	30	30	45	52	55	54	56	57	60	59	42	33	29	25	23	21	21	20
Dec. 26, 1911.....	19	18	19	21	22	22	22	26	42	50	55	58	60	62	60	58	40	31	28	25	24	23	22	21
REDLANDS, CAL.																								
Dec. 25, 1911.....																			36	33	32	31	30	29
Dec. 26, 1911.....	29	30	28	28	27	26	24	26																
UPLAND, CAL.																								
Dec. 25, 1911.....																	38	35	32	30	28		26	
Dec. 26, 1911.....						22	25																	
WHITTIER, CAL.																								
Dec. 25, 1911.....	45	42	41	41	36	41	48	51	54	56			51	42	42	38	36	35	34	31	30	31	32	30
Dec. 26, 1911.....	29			25				41	48	54	50	50	51	52	52	52	50	42	40	39	34	36	38	38

Hourly hygrograph readings.

CLAREMONT, CAL.																								
Dec. 25, 1911.....	35	26	26	24	28	31	33	33	25	24	18	16	18	17	20	16	15	25	29	31	34	37	39	36
Dec. 26, 1911.....	39	40	44	38	43	41	45	40	29	20	10	9	8	7	8	20	24	26	32	29	38	35	37	33
HIGHLAND, CAL. (Thompson Ranch).																								
Dec. 25, 1911.....	49	48	43	41	38	33	30	32	28	24	20	7	15	13	12	10	12	20	21	24	24	27	27	26
Dec. 26, 1911.....	26	33	34	32	31	31	31	31	32	31	28	25	22	21	21	32	39	35	33	33	34	38	37	38
LOS ANGELES, CAL.																								
Dec. 25, 1911.....	28	23	22	21	21	19	18	17	16	12	13	10	9	7	6	5	7	31	36	25	25	25	24	23
Dec. 26, 1911.....	23	24	25	25	24	24	24	24	23	22	26	27	27	26	25	26	47	47	42	43	44	37	36	39
PASADENA, CAL.																								
Dec. 25, 1911.....	22	22	25	23	22	18	23	18	17	18	15	13	18	20	22	25	30	32	31	35	33	32	38	44
Dec. 26, 1911.....	46	47	52	52	51	49	48	44	27	25	25	21	19	18	18	26	45	45	46	49	46	53	57	54